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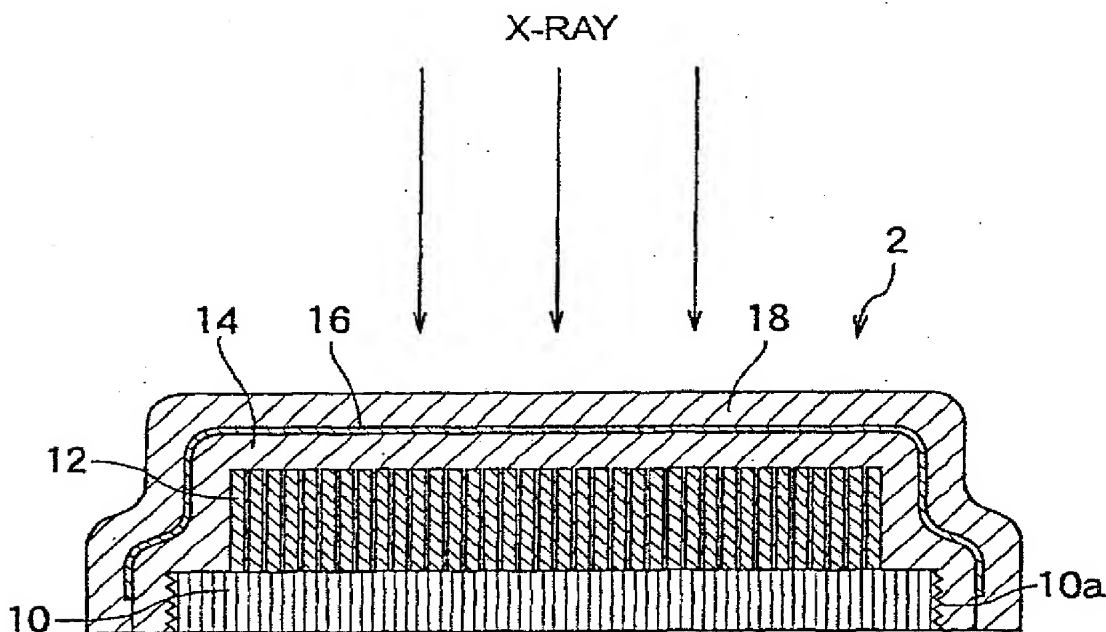
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(54) **SCINTILLATOR PANEL AND RADIATION IMAGE SENSOR**

(57) In a scintillator panel (2) comprising a deliquescent scintillator (12) formed on an FOP (10) and a polyparaxylylene film (14) covering over the scintillator

(12), the FOP (10) comprises a protective film peeling prevention rough (10a) at a side wall portion thereon coming into contact with the polyparaxylylene film (14).

Fig.1



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Description

Technical Field

[0001] The present invention relates to a scintillator panel and a radiation image sensor which are used for medical X-ray photography and the like.

Background Art

[0002] While X-ray sensitive films have been used in medical and industrial X-ray photography, radiation imaging systems using radiation detecting devices have been coming into wider use from the viewpoint of convenience and their storability of photographed results. In such a radiation imaging system, pixel data caused by two-dimensional radiation are acquired by a radiation detecting device as an electric signal, which is then processed by a processing unit, so as to be displayed onto a monitor.

[0003] Conventionally known as a scintillator panel for a radiation detecting device is one disclosed in Japanese Patent Application Laid-Open No. SHO 63-215987. In this scintillator panel, a scintillator made of CsI, which is a typical scintillator material, is formed on a fiber optical plate (FOP), i.e., an optical part constituted by a plurality of optical fibers bundled together. Since this scintillator is deliquescent, a water-impermeable protective film, i.e., polyparaxylylene film, is formed on the upper side of the scintillator, so as to protect the scintillator against moisture.

[0004] However, since side walls of the FOP are ground to flat surfaces, there have been cases where the polyparaxylylene film peels. Namely, when connecting a scintillator panel in which a scintillator is protected by a polyparaxylylene film to an imaging device (e.g., CCD or MOS-type solid-state image sensor) and the like, there are cases where side walls of the FOP are held with fingers, tweezers, or the like or are held with a jig in order to strictly carry out the positioning with respect to the imaging device, whereby the polyparaxylylene film may peel due to a frictional force acting on the polyparaxylylene film, thus allowing water to infiltrate therefrom, which is problematic in that characteristics of the scintillator, such as the resolution thereof in particular, deteriorate.

[0005] It is an object of the present invention to provide a scintillator panel and a radiation image sensor which can prevent the protective film of scintillator from peeling.

Disclosure of the Invention

[0006] The present invention provides a scintillator panel comprising a scintillator formed on a substrate and a transparent organic film covering over the scintillator, wherein the substrate comprises a protective film peeling prevention rough in at least a part of a portion

thereon coming into contact with the transparent organic film.

[0007] According to the present invention, since the transparent organic film for protecting the scintillator is formed so as to reach the protective film peeling prevention rough provided in the substrate, the contact area between the transparent organic film and substrate is enhanced by the protective film peeling prevention rough, whereby the transparent organic film can be prevented from peeling.

[0008] The present invention is characterized in that a side wall of the substrate of the scintillator panel comprises the protective film peeling prevention rough. Since the protective film peeling prevention rough is disposed at a side wall of the substrate, the present invention can prevent the transparent organic film from peeling even when a frictional force acts from the underside of the substrate toward the surface and the like.

[0009] The present invention is characterized in that the substrate of the scintillator panel is a fiber optical plate. According to the present invention, even when connected to an imaging device by way of the fiber optical plate so as to constitute a radiation image sensor, the transparent organic film can be prevented from peeling.

[0010] The present invention is characterized in that the substrate of the scintillator panel is a substrate made of Al. Also, the present invention is characterized in that the substrate of the scintillator panel is a substrate mainly composed of carbon.

[0011] The radiation image sensor of the present invention is characterized in that it further comprises an imaging device on the substrate side of the scintillator panel. Also, the radiation image sensor of the present invention is characterized in that it further comprises an imaging device on the tip side of the scintillator of the scintillator panel. According to the radiation image sensor of the present invention, since the transparent organic film for protecting the scintillator is formed so as to reach the protective film peeling prevention rough provided in the substrate, the contact area between the transparent organic film and substrate is enhanced by the protective film peeling prevention rough, whereby the transparent organic film can be prevented from peeling.

The present invention provides a radiation image sensor comprising a deliquescent scintillator formed on an imaging device and a transparent organic film covering over the scintillator, wherein the imaging device comprises a protective film peeling prevention rough in at least a part of a portion thereof coming into contact with the transparent organic film. According to the present invention, since the transparent organic film for protecting the scintillator is formed so as to reach the protective film peeling prevention rough provided in the imaging device, the contact area between the transparent organic film and imaging device is enhanced by the protective film peeling prevention rough, whereby the transparent

organic film can be prevented from peeling.

[0012] The radiation image sensor of the present invention is characterized in that the imaging device of the radiation image sensor comprises a protective film peeling prevention rough at a side wall thereof. Since the protective film peeling prevention rough is disposed at a side wall of the imaging device, the present invention can prevent the transparent organic film from peeling even when a frictional force acts from the underside of the imaging device toward the surface and the like.

Brief Description of the Drawings

[0013]

Fig. 1 is a sectional view of the scintillator panel in accordance with an embodiment of the present invention;

Fig. 2 is a sectional view of the radiation image sensor in accordance with an embodiment of the present invention;

Fig. 3A is a view showing a step of making the scintillator panel in accordance with an embodiment of the present invention;

Fig. 3B is a view showing a step of making the scintillator panel in accordance with an embodiment of the present invention;

Fig. 3C is a view showing a step of making the scintillator panel in accordance with an embodiment of the present invention;

Fig. 4A is a view showing a step of making the scintillator panel in accordance with an embodiment of the present invention;

Fig. 4B is a view showing a step of making the scintillator panel in accordance with an embodiment of the present invention;

Fig. 5A is a sectional view of the scintillator panel in accordance with an embodiment of the present invention;

Fig. 5B is a sectional view of the scintillator panel in accordance with an embodiment of the present invention;

Fig. 6A is a chart showing the relationship between the surface roughness R_a of substrate in an embodiment of the present invention and the particle size of powder for grinding the substrate;

Fig. 6B is a chart showing the relationship between the surface roughness R_{max} of substrate in an embodiment of the present invention and the particle size of powder for grinding the substrate;

Fig. 7A is a chart showing the relationship between the surface roughness R_a of substrate and the adhesion of the amorphous carbon substrate and a protective film; and

Fig. 7B is a view showing the relationship between the surface roughness R_{max} of substrate and the adhesion of the amorphous carbon substrate and a protective film.

Best Modes for Carrying Out the Invention

[0014] In the following, embodiments of the present invention will be explained with reference to the drawings. Fig. 1 is a sectional view of a scintillator panel 2 in accordance with an embodiment of the present invention. As shown in Fig. 1, the side wall of an FOP 10 in the scintillator panel 2 is provided with a protective film peeling prevention rough 10a. Also, one surface of the FOP 10 is formed with a scintillator 12 having a columnar structure adapted to convert incident radiation into visible light. Used in the scintillator 12 is TI-doped CsI.

[0015] The scintillator 12 formed on the FOP 10 is covered with a first polyparaxylylene film (transparent organic film) 14 acting as a protective film, whereas the end portion of the first polyparaxylylene film 14 is formed so as to reach the protective film peeling prevention rough 10a. A surface of the first polyparaxylylene film 14 is formed with an Al film 16, whereas the surface of Al film 16 and the surface of first polyparaxylylene film 14 not formed with the Al film 16 are formed with a second polyparaxylylene film 18. This scintillator panel 2 is used as a radiation image sensor when connected to an unshown imaging device (e.g., a CCD, a thin-film transistor with a photodiode array, or a MOS-type solid-state imaging device) by way of the FOP 10.

[0016] Fig. 2 is a sectional view of a radiation image sensor 4 in accordance with an embodiment. As shown in Fig. 2, the side wall of an imaging device (CCD) 20 of the radiation image sensor 4 is provided with a protective film peeling prevention rough 20a. A scintillator 12 having a columnar structure is formed on the light-receiving surface of imaging device 20. The scintillator 12 is covered with a first polyparaxylylene film (transparent organic film) 14 acting as a protective film, whereas the end portion of the first polyparaxylylene film 14 is formed so as to reach the protective film peeling prevention rough 20a. A surface of the first polyparaxylylene film 14 is formed with an Al film 16, whereas the surface of Al film 16 and the surface of first polyparaxylylene film 14 not formed with the Al film 16 are formed with a second polyparaxylylene film 18.

[0017] With reference to Figs. 3A to 4B, steps of making the scintillator panel 2 will now be explained. First, the side wall of FOP 10 is formed with the protective film peeling prevention rough 10a (see Fig. 3A). Namely, in a state where the part of FOP 10 other than its side wall is protected by a vinyl tape, a sandblast treatment is carried out at a pressure of 2 kg/cm² with #800-mesh alumina. This sandblast treatment forms the protective film peeling prevention rough 10a in which $R_a = 0.32 \mu\text{m}$ and $R_{max} = 2.1 \mu\text{m}$ (where R_a (center line average roughness) and R_{max} (maximum height) are defined by JIS-B0601) according to the surface roughness measurement by use of a surface roughness meter (Surfcom 600A, Tokyo Seimitsu).

[0018] Subsequently, on one surface of the FOP 10, columnar crystals of TI-doped CsI are grown by vapor

deposition method, so as to form the scintillator 12 by a thickness of 200 μm (see Fig. 3B). Since CsI, which forms the scintillator 12, is high in moisture absorbency so that it will deliquesce by absorbing vapor in the air if left exposed, the first polyparaxylylene film 14 is formed by CVD method in order to prevent this from occurring. Namely, the substrate 10 having formed the scintillator 12 is put into a CVD apparatus, and the first polyparaxylylene film 14 is formed with a thickness of 10 μm . As a consequence, the first polyparaxylylene film 14 is formed on all surfaces of the scintillator 12 and reaches the position of the protective film peeling prevention rough 10a disposed at the side wall of FOP 10 (see Fig. 3C).

[0019] Then, the Al film 16 is deposited by a thickness of 300 nm on the surface of first polyparaxylylene film 14 on the scintillator 12 side (see Fig. 4A). Here, the Al film 16 is formed in an area covering over the scintillator 12, since it is aimed at improving the moisture resistance of scintillator 12.

[0020] Further, on the surface of Al film 16 and the surface of first polyparaxylylene film 14 not formed with the Al film 16, the second polyparaxylylene film 18 is formed with a thickness of 10 μm again by CVD method (see Fig. 4B). When this step is completed, the making of scintillator panel 2 ends.

[0021] The radiation image sensor 4 shown in Fig. 2 is made by a method similar to the method of making scintillator panel 2. Namely, the side wall of imaging device 20 is formed with the protective film peeling prevention rough 20a by a method similar to that used for forming the side wall of FOP 10 with the protective film peeling prevention rough 10a. Subsequently, by a method similar to that in the case of making the scintillator panel, the scintillator 12 is formed, and the first polyparaxylylene film 14, Al film 16, and second polyparaxylylene film 18 are formed on the scintillator 12. When this step is completed, the making of radiation image sensor 4 ends.

[0022] Since the side wall of FOP 10 is provided with the protective film peeling prevention rough 10a, the scintillator panel 2 in accordance with this embodiment can prevent the end portion of first polyparaxylylene film 14 from peeling due to friction and the like. Also, since the side wall of imaging device 20 is provided with the protective film peeling prevention rough 20a, the radiation image sensor 4 in accordance with this embodiment can prevent the end portion of first polyparaxylylene film 14 from peeling due to friction and the like. Therefore, the moisture resistance of scintillator 12 can remarkably be improved.

[0023] Though the protective film peeling prevention rough 10a is formed by subjecting the side wall of FOP 10 to the sandblast treatment at a pressure of 2 kg/cm² with #800-mesh alumina in the above-mentioned embodiment, the protective film peeling prevention rough 10a may be formed by carrying out a sandblast treatment at a pressure of 2 kg/cm² with #1500-mesh alumi-

na. The latter case yields a protective film peeling prevention rough in which $R_a = 0.19 \mu\text{m}$ and $R_{\text{max}} = 1.42 \mu\text{m}$ according to the surface roughness measurement by use of a surface roughness meter (Surfcom 600A, Tokyo Seimitsu).

[0024] Also, the protective film peeling prevention rough 10a may be formed by excimer laser irradiation, wet etching processing, and the like. When forming grooves of 500 μm (l) X 10 μm (w) X 10 μm (d), for example, in the case of excimer laser irradiation, it is preferred that at least three of them be formed per 1 mm². It is also preferred that the ratio of width (w)/depth (d) in the grooves be 1.0 or less.

[0025] In the case of wet etching processing, on the other hand, numeral pits having a depth of 5 μm can be formed when the FOP 10 are immersed into a 1-N HNO₃ solution for 5 minutes while the part other than the side wall thereof is protected. The side wall of FOP 10 may be cut with a cutter knife or the like, so as to form the protective film peeling prevention rough 10a. The protective film peeling prevention rough 10a may also be formed by Carborundum grinding.

[0026] Though CsI(Tl) is used as the scintillator in the above-mentioned embodiment, it is not restrictive; and CsI(Na), NaI(Tl), LiI(Eu), KI(Tl), and the like may also be used.

[0027] While FOP and CCD are used as the substrate for forming a scintillator and the imaging device, respectively, in the above-mentioned embodiment, substrates made of Al, substrates mainly composed of carbon such as those made of C (graphite) and those made of amorphous carbon, substrates made of Be, substrates made of SiC, and the like which are substrates having a favorable X-ray transmissivity may also be used as well. Also, glass substrates may be used.

[0028] Figs. 5A and 5B are views showing scintillator panels in which a scintillator 12 is formed on a surface of a substrate 30 made of amorphous carbon, and a first polyparaxylylene film 14 for protecting the scintillator 12, a transparent inorganic film (SiO₂ film) 22, and a second polyparaxylylene film 18 are formed. In the scintillator panels shown in Figs. 5A and 5B, all surfaces of the amorphous carbon substrate 30 and scintillator 12 are covered with the first polyparaxylylene film 14 and the second polyparaxylylene film 18. A protective film peeling prevention rough 30a is formed on the surface of amorphous carbon substrate 30 formed with the scintillator 12 at a part not covered with the scintillator 12 in the scintillator panel of Fig. 5A, and a protective film peeling prevention rough 30a is formed on the surface of Al substrate 30 not formed with the scintillator 12 in the scintillator panel of Fig. 5B, whereby the first polyparaxylylene film 14 formed on the amorphous carbon substrate 30 can be prevented from floating up and peeling in these cases. The side wall portion of Al substrate 30 may further be provided with a protection film peeling prevention rough in these cases. Here, the transparent inorganic film may be any of Al₂O₃, TiO₂,

In_2O_3 , SnO_2 , MgO , SiN , MgF_2 , LiF , CaF_2 , AgCl , and SiNO .

[0029] When making the scintillator panel of the above-mentioned embodiment, the relationship between the adhesion of the substrate and protective film and the magnitude of protective film peeling prevention rough was studied. Amorphous carbon (a-C) sheets having a thickness of 1 mm were ground with SiC grinding powders whose particle size varies from #600 to #10000 (seven kinds of #600, #800, #1000, #1500, #2000, #4000, and #10000), so as to prepare amorphous carbon substrates having different surface roughness values, and then their surface roughness values R_a and R_{max} were measured with a surface roughness meter. The relationships between the particle size of grinding powder and R_a and R_{max} are shown in Figs. 6A and 6B.

[0030] Next, CsI was deposited by 200 μm on each of thus prepared amorphous carbon substrates, a polyparaxylylene film was subsequently formed thereon by CVD method, and then the relationships between the adhesion of CsI and the amorphous carbon substrate, the adhesion of substrate and protective film at the protective film peeling prevention rough 30a in Fig. 5B in particular, and R_a and R_{max} were studied, whereby the results shown in Figs. 7A and 7B were obtained.

[0031] As can be seen from these charts, it has been found that the case where the film is formed on an amorphous carbon substrate having an R_a of at least 0.1 μm and an R_{max} of at least 0.8 μm is effective in adhesion.

[0032] Namely, it has been found that, in the case where the above-mentioned FOP and amorphous carbon are used as the substrate, the surface roughness functioning as the protective film peeling prevention rough has an R_a of at least 0.1 μm and an R_{max} of at least 0.8 μm .

[0033] The scintillator panel using the amorphous carbon substrate 30 is used as a radiation image sensor when an imaging device is disposed on the tip side of the scintillator 12. In the case where a substrate made of Al, a substrate made of Be, or the like is used, the scintillator panel is similarly used as a radiation image sensor. In the case where a glass substrate is used, the scintillator panel is used as a radiation image sensor when an imaging device is disposed on the glass substrate side with a lens interposed therebetween.

[0034] The magnitude of protective film peeling prevention rough described in the foregoing is applicable not only to the FOP and amorphous carbon substrate, but also to substrates made of Al and other materials. The protective film in the above-mentioned embodiment includes not only polyparaxylylene, but also polymonochloroparaxylylene, polydichloroparaxylylene, polytrichloroparaxylylene, polyfluoroparaxylylene, polyfluoroparaxylylene, polydimethylparaxylylene, polydiethylparaxylylene, and the like.

[0035] According to the scintillator panel of the present invention, since the transparent organic film for

protecting the scintillator is formed so as to reach the protective film peeling prevention rough provided in the substrate, the contact area between the transparent organic film and substrate is enhanced by the protective film peeling prevention rough, so that the transparent organic film can be prevented from peeling, whereby the moisture resistance of scintillator can be improved. In the case where the protective film peeling prevention rough is disposed at a side wall of the substrate, the transparent organic film can be prevented from peeling even when a frictional force acts from the underside of the substrate toward the surface and the like.

[0036] According to the radiation image sensor of the present invention, since the transparent organic film for protecting the scintillator is formed so as to reach the protective film peeling prevention rough provided in the imaging device, the contact area between the transparent organic film and imaging device is enhanced by the protective film peeling prevention rough, so that the transparent organic film can be prevented from peeling, whereby the moisture resistance of scintillator can be improved. In the case where the protective film peeling prevention rough is disposed at a side wall of the imaging device, the transparent organic film can be prevented from peeling even when a frictional force acts from the underside of the imaging device toward the surface and the like.

Industrial Applicability

[0037] As in the foregoing, the scintillator panel and radiation image sensor in accordance with the present invention are suitably usable for medical and industrial X-ray photography and the like.

Claims

1. A scintillator panel comprising a scintillator formed on a substrate and a transparent organic film covering over said scintillator,
wherein said substrate comprises a protective film peeling prevention rough in at least a part of a portion thereon coming into contact with said transparent organic film.
2. A scintillator panel according to claim 1, wherein said substrate comprises said protective film peeling prevention rough at a side wall thereof.
3. A scintillator panel according to claim 1 or 2, wherein said substrate is a fiber optical plate.
4. A scintillator panel according to claim 1 or 2, wherein said substrate is a substrate made of Al.
5. A scintillator panel according to claim 1 or 2, wherein said substrate is a substrate mainly composed of

carbon.

6. A radiation image sensor further comprising an imaging device on said substrate side of said scintillator panel according to claim 3. 5
7. A radiation image sensor further comprising an imaging device on a tip side of said scintillator in said scintillator panel according to claim 4 or 5. 10
8. A radiation image sensor comprising a scintillator formed on a light-receiving surface of an imaging device and a transparent organic film covering over said scintillator, 15
wherein said imaging device comprises a protective film peeling prevention rough in at least a part of a portion thereof coming into contact with said transparent organic film.
9. A radiation image sensor according to claim 8, 20
wherein said imaging device comprises a protective film peeling prevention rough at a side wall thereof.

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Fig. 1

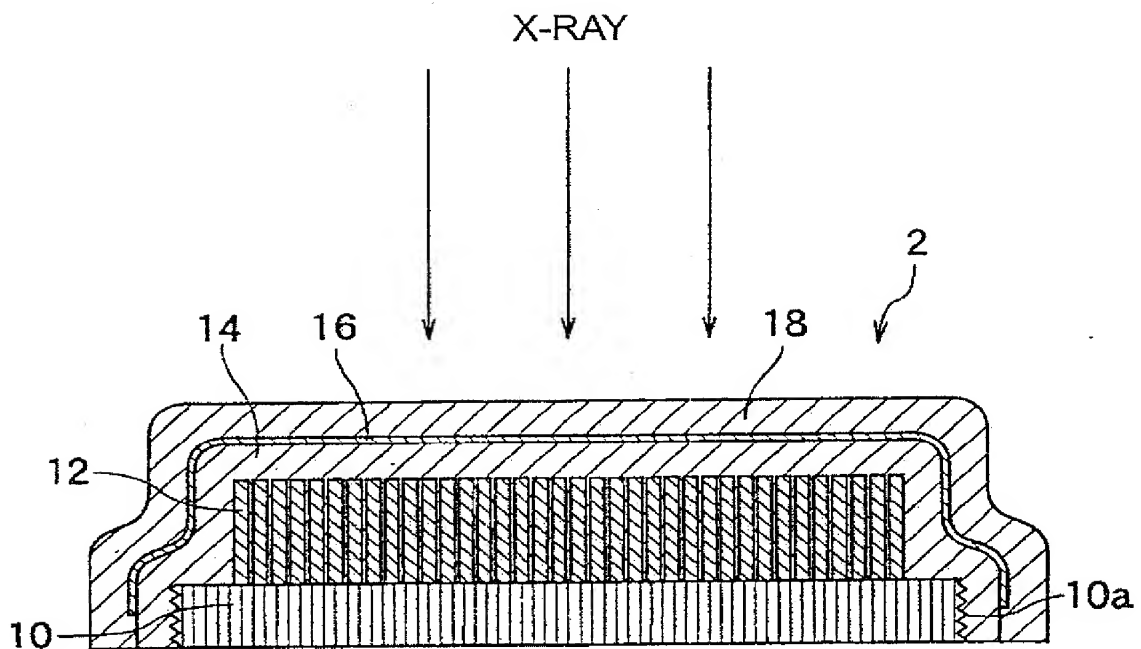


Fig.2

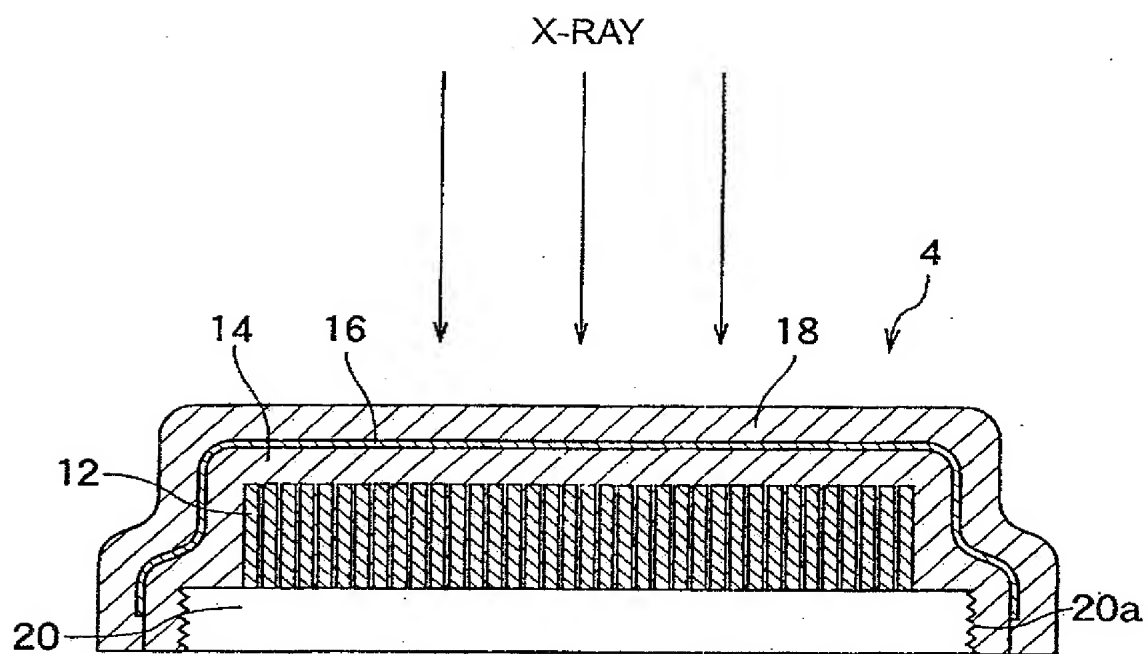


Fig.3A

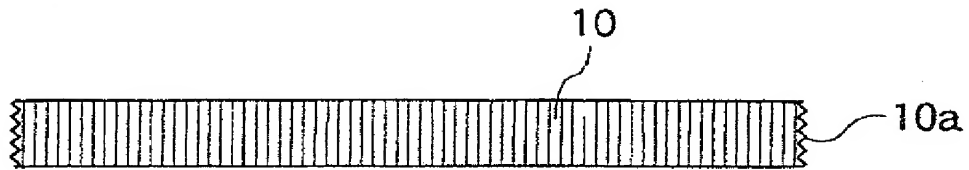


Fig.3B

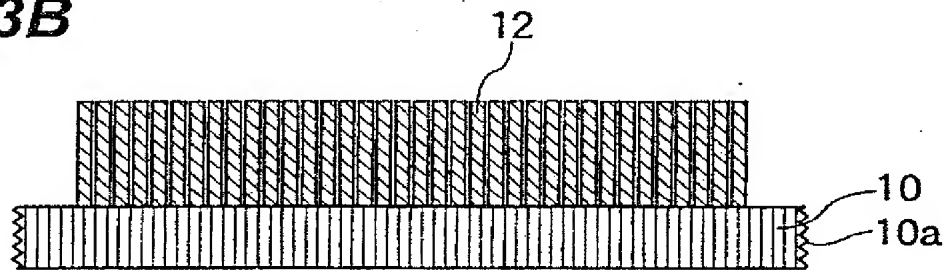


Fig.3C

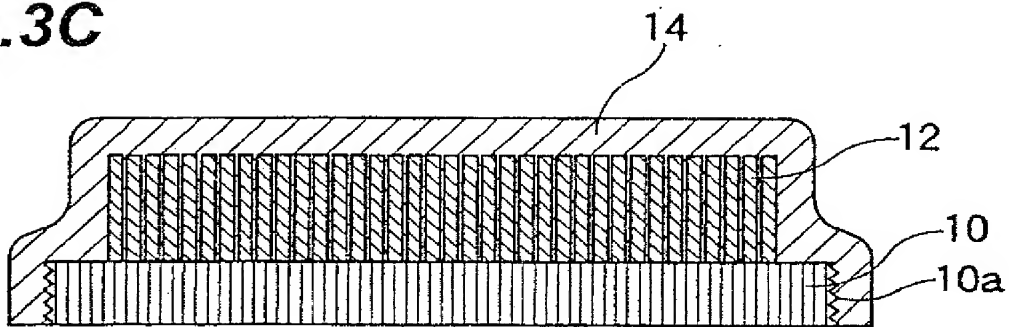


Fig.4A

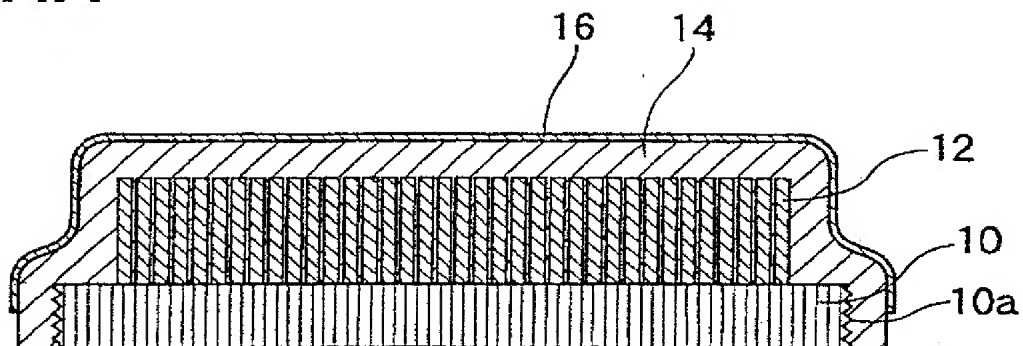


Fig.4B

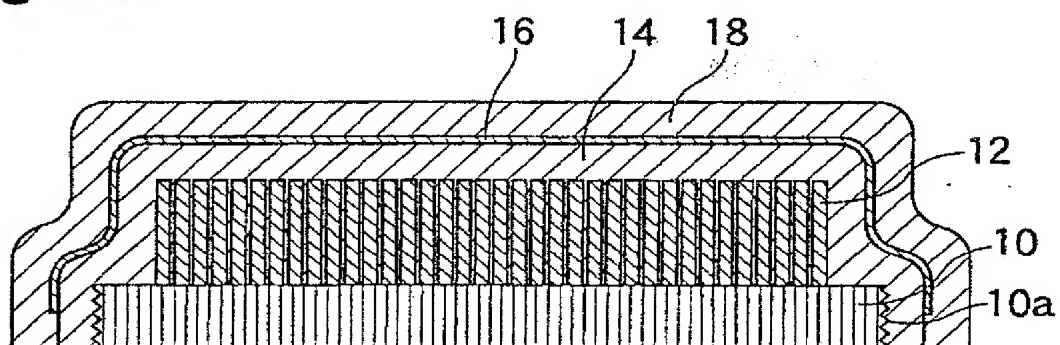


Fig.5A

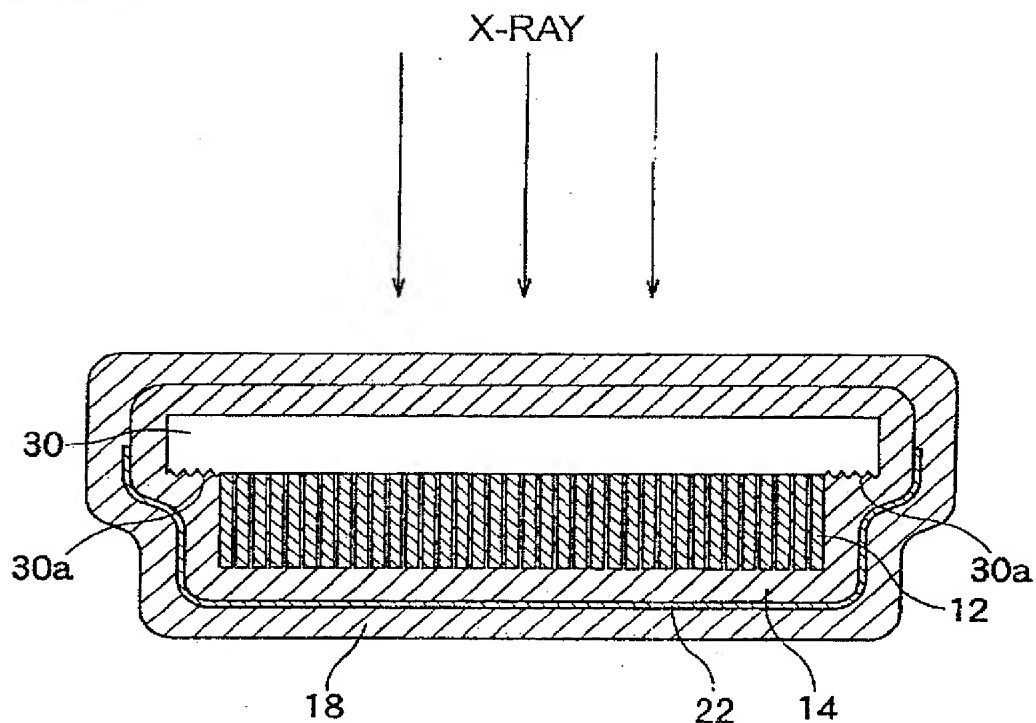


Fig.5B

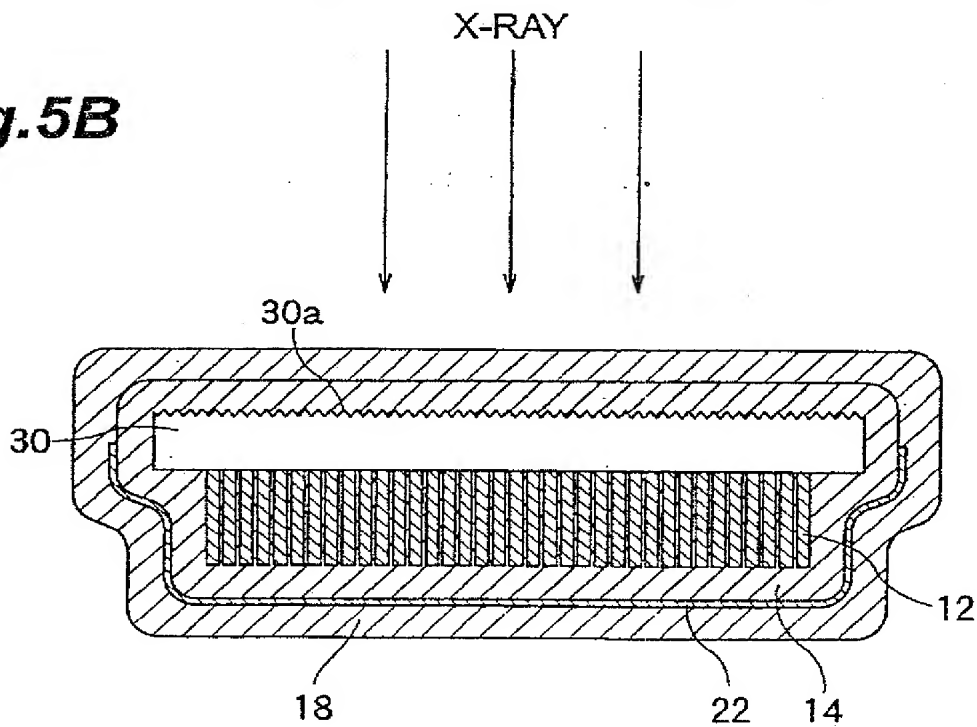


Fig. 6A

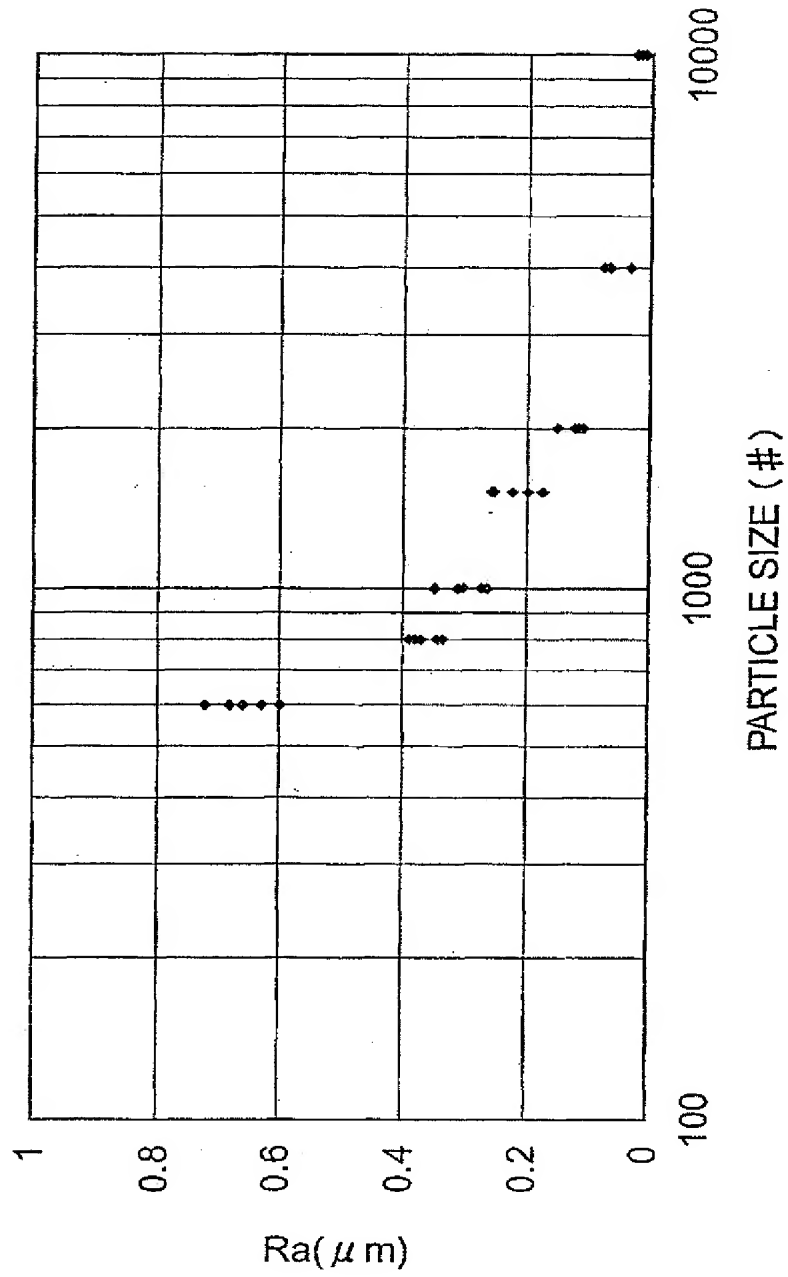


Fig. 6B

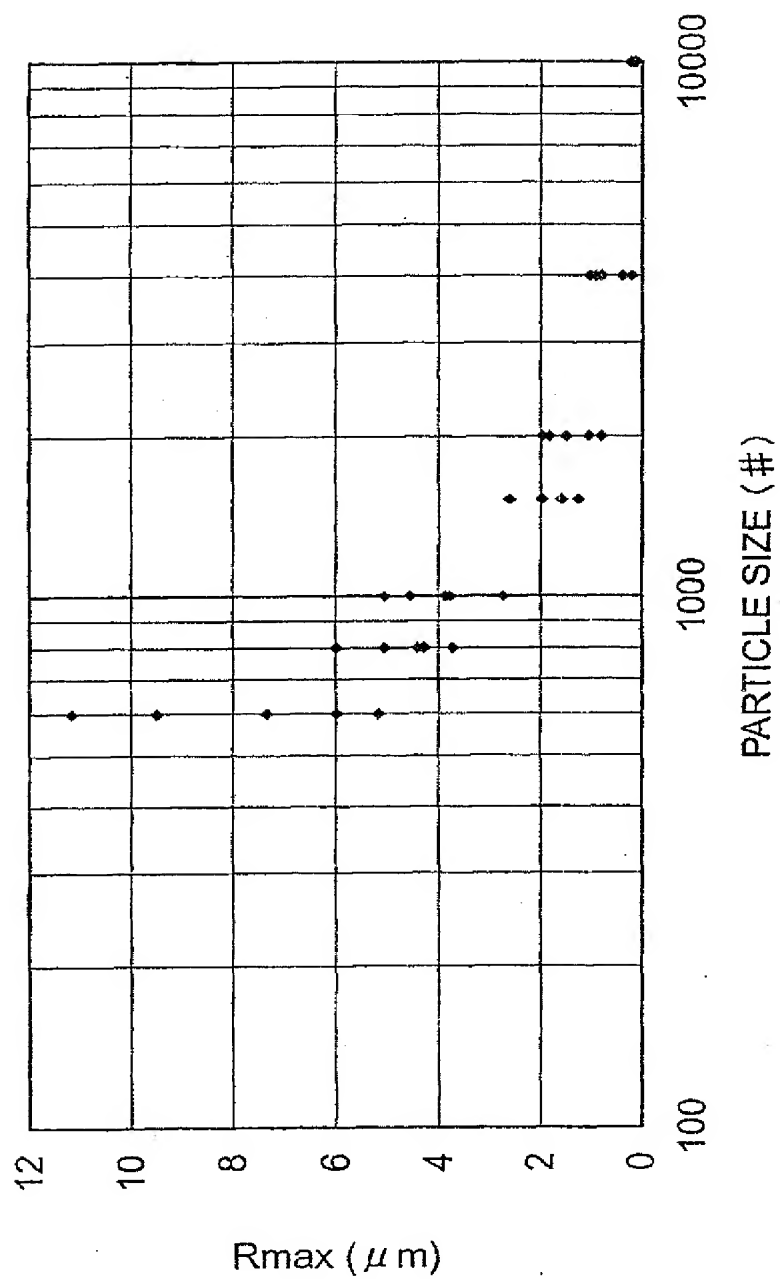
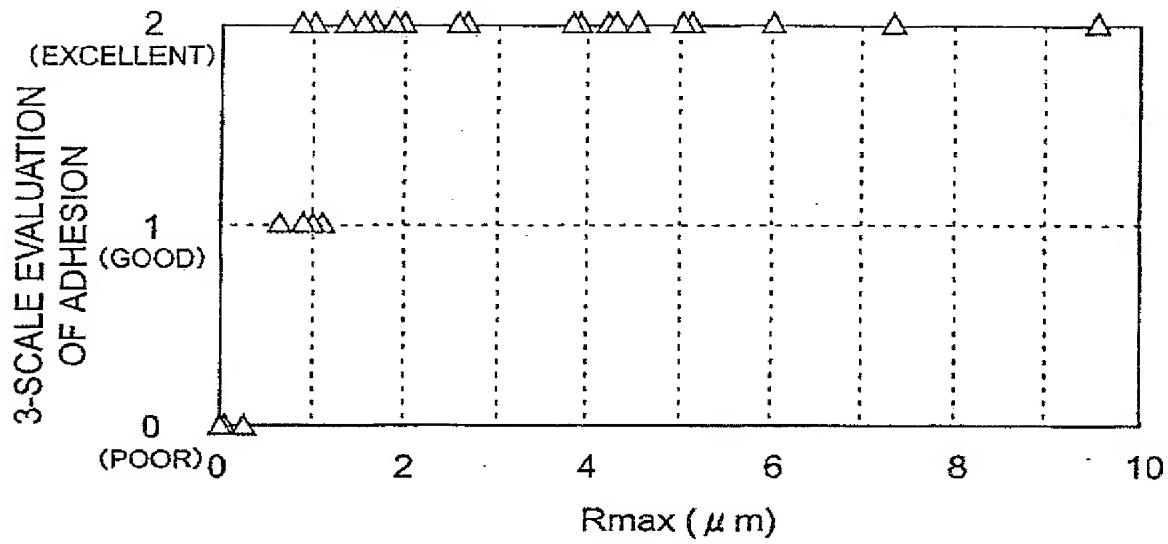
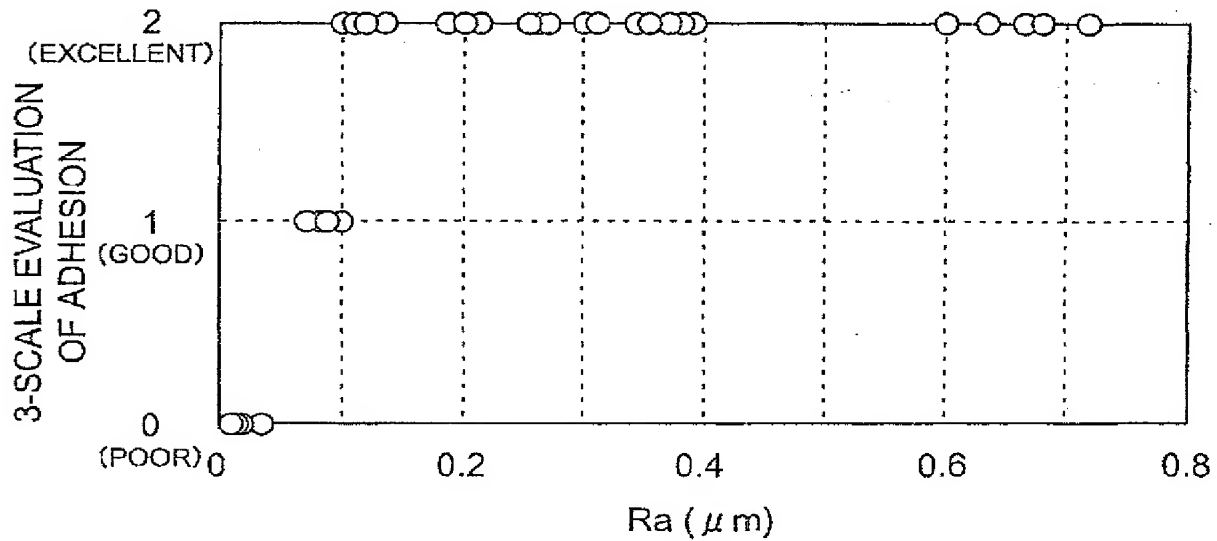


Fig.7A**Fig.7B**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP99/03268

A. CLASSIFICATION OF SUBJECT MATTER Int.Cl. ⁵ G01T1/20		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) Int.Cl. ⁶ G01T1/20		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Toroku Jitsuyo Shinan Koho 1994-1999 Kokai Jitsuyo Shinan Koho 1971-1999 Jitsuyo Shinan Toroku Koho 1996-1999		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Reference 1: JP, 7-27863, A (Hamamatsu Photonics K.K.), 31 January, 1995 (31. 01. 95), Par. Nos. [0013] to [0022] ; Figs. 1, 3, 4	1-6, 8
Y	Reference 2: JP, 61-29788, A (Mitsubishi Atomic Power Industries, Inc.), 10 February, 1986 (10. 02. 86), Full text ; Figs. 1 to 3	1-6, 8
Y	Reference 3: JP, 8-227520, A (Fuji Electric Co., Ltd.), 3 September, 1996 (03. 09. 96), Full text ; Fig. 1	1-6, 8
Y	Reference 4: JP, 62-216234, A (Shimadzu Corp.), 22 September, 1987 (22. 09. 87), Full text ; Fig. 1	1-6, 8
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "Z" document member of the same patent family		
Date of the actual completion of the international search 24 August, 1999 (24. 08. 99)		Date of mailing of the international search report 14 September, 1999 (14. 09. 99)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
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Form PCT/ISA/210 (second sheet) (July 1992)

